PB-228 032

COST EFFECTIVENESS IN WATER QUALITY PROGRAMS. A DISCUSSION

Environmental Protection Agency
Washington, D.C.

October 1972

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 228 032

Cost Effectiveness in Water Quality Programs

A Discussion

This document discusses critical cost effectiveness issues that the Environmental Protection Agency believes must be addressed in water quality planning. Inquiries and comments on this water quality planning discussion should be directed to the Office of Air and Water Programs, EPA.

ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

i.

68

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

Contents

I. The Concept 1
- Intent 1
- Definition 3
- Application 5

II. Projecting Wastewater Flows 6
- Existing Flows 6
- Population 7
- Industry 10

III. Assembling a Wastewater Systems Configuration 12
- Systems Components and Sites 14
- Combined Municipal-Industrial Systems 15
- Individual vs. Central Treatment Systems 16

IV. Selecting the Treatment Process 20
- Upgrading the Present Facility 20
- Reliability and Flexibility 22
- Reuse of Wastewater 24
- Water Disposal vs. Land Disposal of Effluent 25
- Ultimate Disposal of Liquid, Sludge, and Other Wastes 27

V. Scheduling Construction of Facilities 29
- Short Design Periods 30
- Long Design Periods 31
- Financing 32
- Treatment Plants 33
- Interceptor Sewers 34

Appendices -
- A. Review Questions for Planning Municipal Wastewater Treatment Facilities 36
- B. Summary of National Population Trends 43

Tables -
- I. Population Change, 1960-1970 47
- II. Standard Metropolitan Statistical Areas 48

Figures -

1. Non-SMSA Counties, 1960-70 Population Growth (Boston Region) 55
2. Non-SMSA Counties, 1960-70 Population Growth (New York) 56
3. Non-SMSA Counties, 1960-70 Population Growth (Philadelphia) 57
4. Non-SMSA Counties, 1960-70 Population Growth (Atlanta) 58
5. Non-SMSA Counties, 1960-70 Population Growth (Chicago) 59
6. Non-SMSA Counties, 1960-70 Population Growth (Dallas) 60
7. Non-SMSA Counties, 1960-70 Population Growth (Kansas City) 61
8. Non-SMSA Counties, 1960-70 Population Growth (Denver) 62
9. Non-SMSA Counties, 1960-70 Population Growth (San Francisco) 63
10. Non-SMSA Counties, 1960-70 Population Growth (Seattle) 64
11. Non-SMSA Counties, 1960-70 Population Growth (National Summary) 65
12. Comparison of Non-SMSA's and SMSA's Rate of Population Change, 1960-70 66

I. The Concept

Cost effectiveness has been a Federal water quality control program objective for several years. It was first highlighted, however, in the July 1970 Environmental Protection Agency regulations (18 CFR Part 601) concerning basin and regional/metropolitan water quality management plans and municipal wastewater projects. Subsequent Federal guidelines and regulations have further emphasized the need for cost effectiveness in water quality management.

The cost effectiveness issues discussed herein are critical in the formulation of acceptable water quality plans and projects. Such issues will become increasingly acute as even greater amounts of Federal funds are directed towards water pollution control.

Intent

This publication is intended to help design engineers, water quality management planners, and decision-makers at all levels of government apply cost effectiveness for the greatest clean-up possible for public pollution control dollars. In conjunction with several

earlier EPA publications (*) it should be used in preparing and reviewing all water quality plans and designs for municipal wastewater systems and projects. It should be of particular value throughout the planning and project formulation process.

Ultimately, the effectiveness of any water pollution control plan or project is measured by whether it succeeds in meeting and maintaining water quality standards or other appropriate goals. But there are often alternative strategies available for achieving this fundamental objective.

The planning role in water quality management is to develop and evaluate the alternatives and determine the strategy for attaining the water quality goals at the least cost. The (EPA) Guidelines for Water Quality Management Planning discuss in detail the methods to determine the cost-effective plan.

(*) Federal Guidelines for Design, Operation and Maintenance of Wastewater Treatment Facilities, EPA, September 1970, and supplemental technical bulletins. Guidelines for Water Quality Management Planning, EPA, January 1971. Federal Guidelines for Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems, EPA, October 1971. Draft Guidelines and Procedures for Preparation of Environmental Impact Statements, EPA, Federal Register, January 20, 1972 (40 CFR Part 6).

Two types of plans are required by the Guidelines: basin and areawide. The basin plan centers on water quality management in the hydrologic system. It establishes basinwide priorities and constraints and allocates the assimilative capacity for meeting water quality standards among the various wastewater sources. Of special relevance to this discussion, the areawide (or metropolitan/regional) plan selects and schedules the systematic application of legal and technological tools to achieve and maintain water quality standards within certain politically defined areas. These may be population and industrial concentrations or other water quality problem areas. Some critical questions posed in areawide planning are location and sizing of sewers and treatment plants, process selection, consolidation of facilities, and control of growth and development for environmental reasons.

Definition

An effective plan will set forth the actions required to achieve and maintain water quality standards or other goals, now and in the future. It will prevent the degradation of high quality water bodies. It will contain timetables for action. And it will contain price tags--the capital costs of construction, and the on-going costs of operation and maintenance.

The objective of cost-effective planning for water pollution control is to minimize the total of those costs, whether they are paid by

the local, state or Federal government.

On the local level, a cost-effective plan for a defined local planning area will minimize the total public cost of pollution control while satisfying the criteria of controlling environmental damage, meeting social goals, and providing reliable performance. In other words, as a plan is implemented, the community will incur capital costs for construction and on-going costs for operation and maintenance.

On the national level, cost effectiveness means that local projects which provide the greatest overall improvement in water quality, in terms of beneficial social and environmental impact, will be approved before those which provide less improvement. This is especially important in determining priorities within a metropolitan or regional area, a river basin, or a state.

Cost effective water quality management planning must be integrated with plans for all public services associated with area development. The area's land-use goals should provide the basis for all desired development. Planning for needed wastewater collection and treatment facilities must then stem from the land-use goals, and development of these facilities should parallel development of other services such as water supply, schools and transportation, as well as total urban development itself.

Application

This discussion applies the concept of cost effectiveness to four major components of the water quality management planning process--projecting wastewater flows, assembling a wastewater systems configuration, selecting the treatment process, and scheduling construction of facilities.

All questions posed herein may not be relevant to all areas or all plans under consideration. But all pertinent sections should be used in developing and reviewing a plan or a grant application for a project.

Finally, it should be noted that this publication is not intended to provide cost effectiveness criteria for approval or rejection of a plan. Rather, it is intended as an introduction to the concept of cost effectiveness. EPA intends to expand upon this document with complementary documents or guidelines related specifically to the evaluation and screening of alternative plans and projects.

II. Projecting Wastewater Flows

Many factors are involved in projecting wastewater flows in a planning area. Although analysis of the existing wastewater flows is the beginning point in the projection and planning task, determination of population trends is obviously of equal importance. Once these two major factors have been evaluated other possible planning determinants are considered, such as:

- Extensions of the domestic sewer service area,
- Increases in per capita domestic wastewater production,
- Increases in discharges from connected industrial sources, and
- New industrial connections.

Existing Flows

Review and evaluation of the existing wastewater flows should be done as part of the analysis of the existing system which is already required by the Federal Guidelines for Design, Operation and Maintenance of Wastewater Treatment Facilities (EPA). Those guidelines also require remedial measures if flows appear excessive in relation to population, and commercial and industrial users served. The required analysis should provide answers to several questions, including:

1. Is there excessive infiltration into the system?

2. Are there illegal storm water connections, and if so, what is being done about them?

3. Are sewer ordinances adequate and are they enforced?

4. Are reported waste flows reasonable and are they based on actual in-plant measurements?

5. Are reported per capita waste loadings representative?

6. How were they determined and is the method defensible?

It should be noted that in some instances the public is showing an interest in technological changes to reduce water consumption. This could curtail the per capita wastewater discharge in the near future. Substantial savings can be made--in capital investment and in operation and maintenance costs--by reducing wastewater volume. Thus all probable institutional and legal techniques for reducing wastewater volume should be considered. (For example: Building code changes to restrict the size of water closet tanks, the flow of showerheads, etc.)

Population

The overall rate of population growth in the United States has been declining. But at the same time there have been large shifts in population as migration has continued from rural to urban areas. And in urban areas, much of the population growth has occurred in

the suburban ring surrounding core cities, while population in the core cities has remained generally constant. Some moderate or small rural communities are developing into regional commercial and service centers, and are likely to continue to grow. But population in most rural communities is stable or declining.

Against that general background, water quality planners analyze the characteristics of population trends in their given planning area. To assist, population statistics and projections are available for most of the heavily populated areas of the nation. Projections are made by regional planning agencies, by state agencies (commerce, planning, etc.) and by the Federal government (the Commerce Department's Bureau of the Census, Office of Business Economics, and Bureau of Economic Analysis).

The Census Bureau's Standard Metropolitan Stati stical Area (SMSA) studies of the larger American cities are a particularly valuable planning resource. However, areas outside SMSA's are not studied in such detail, and a complicating factor in smaller cities is their vulnerability to annexation by neighboring cities. Since the smallest stable geographic boundary is the county, population by counties has been tabulated for non-SMSA counties and subdivided according to population of the largest town in the county. (Appendix B in this publication

contains compilations of 1970 Census data that may be helpful in areas for which no projections are readily available. Tabulations are also presented for each EPA region in Table 1.)

But whatever sources are used to project population growth, planners should keep these questions in mind:

1. Are projected population growth rates realistic?

2. What is their basis?

3. Do the figures distinguish between total population and sewered population?

4. How does the projection compare with existing data?

5. If discrepancies exist, what caused them?

6. What, if any, land use constraints were considered in the population projections?

If evaluation produces population projections which are inconsistent with present local trends, they should be investigated further. If the service area growth rate appears unusual, explanation should be given. Incorrect projections in the past have resulted in overeapacity in some instances, overloading in others. More careful planning today will avoid this in the future.

Population shifts, as well as growth, should also be considered within the planning area. These shifts may have a greater impact than net increases in population. For example, even though the population

growth rate may remain unchanged, will additional sewer lines be required in different parts of the area because of population shifts? From the core city to the suburbs? By extensions of the urban fringe? By converting older homes from septic tanks to sewer service?

Moreover, population estimates for water quality planning should be consistent with population growth estimates used by a state in preparing its implementation plan submitted to EPA in compliance with the Clean Air Act of 1970.

Industry

Industrial connections to the municipal system should also be considered in projecting future wastewater flows. Planners should bear in mind such questions as:

1. Do already connected industrial sources expect their discharges to increase, decrease, or remain constant?

2. Will the nature of discharges from connected industries change?

3. What are the prospects of unconnected industries hooking up with the municipal system in the future?

4. What are the prospects of new industries locating in the area, and what will this mean for industrial service as well as increased domestic service?

New or expanded industry can obviously affect population growth and, if added to the municipal system, can obviously produce changes often not considered in projections. Also, because industrial effluent is usually more concentrated than municipal sewage, industrial wastewater can have a proportionately greater impact on a municipal system than its volume along would indicate.

Another factor: Increasing water supply and waste treatment costs appear to be causing more intensive use and reuse of water by the industrial sector, where production is rising faster than the volume of wastewater discharges. (See Volume I of EPA's 1972 Economics of Clean Water for a detailed discussion of this trend.) So, this too should be considered, along with the impact of increasing public interest in conservation practices for reducing domestic water use.

In sum, while population is the predominant indicator, wastewater flow projections must consider all applicable factors.

III. Assembling a Wastewater Systems Configuration

In formulating a cost-effective plan to address the pollution sources within a basin or metro/regional area the water quality planner considers all feasible alternatives. Except in the simplest cases where there is only one practicable means of achieving water quality goals, the planner should identify feasible alternative courses to achieve the water quality goals, itemize and compare the costs of major alternatives, and state the basis for selecting the chosen alternative.

During the system selection process, the planner examines these questions:

1. Has upgrading of existing facilities been considered? What are the advantages and disadvantages?

2. Has regionalization of facilities been considered?

3. Has a combined municipal-industrial waste treatment system been considered?

4. Has recycling been considered?

5. Has a soil disposal system been considered?

6. What legal and other institutional methods of regulating waste discharges, reducing collection costs, etc. were considered?

7. Are cost estimates presented for all feasible alternatives, and are they consistent with generalized cost curves for the area?

Although total cost is a basic criterion for system selection, reliability and flexibility criteria are also important. These latter criteria include the contributions of the entire system, or individual projects, toward achieving and maintaining water quality goals, given continually changing conditions. The possibility of utilizing present facilities, where upgrading may be the most cost-effective solution, should be a first consideration. And, opportunities for reuse and recycling, or perhaps land disposal of wastewater, must also be explored, especially where there is a resource management need for such water conservation. (These subjects are more fully discussed in Chapter IV.)

The first step in assembling a cost effective wastewater systems configuration is to determine the number and location of treatment plants within the metro/regional planning area and the economics of a possible move from the old system to a new system. Then, the extent that the systems configuration should serve all the area's municipal and industrial waste sources and whether or not to combine municipal and industrial treatment must be determined. As the systems configuration assumes shape, these factors and issues must be reexamined to consider the changing environmental and social issues and conditions bearing upon the planning decisions.

System Components and Sites

Since a metro or regional waste treatment system will generally contain the basic components of sewers, pumping stations, and treatment facilities, the cost effective plan or project will consist of a mix of those components. Selection of the components will be based on a systematic comparison of the range of alternatives.

Identification of acceptable and available treatment sites, along with tributary areas to these sites, should be made with an eye to possible integration into the existing system or to centralization, if desired. Evaluation of alternative combinations utilizing subsets of the available sites will yield a single cost-effective solution. Although costs will be an important parameter, continuous recognition must be given to the importance of relevant environmental and social factors.

This analysis is rigorous and embodies the entire spectrum of water quality management planning. There is no general criteria which permits screening of alternatives. The assessment of each site and each area is unique.

When evaluating the system for water disposal (rather than land disposal) of the effluents and when deciding between a decentralized or a centralized system, the principal tradeoff involves the economies of scale of larger treatment facilities versus the added costs of conveying the wastewater. The conveyance costs are largely a function of distance, gradient, soil type, and volume, whereas the treatment costs

vary with the process selected, volume of wastewater, and the organic load. Effluent limitations, based on meeting receiving water quality standards, or other applicable criteria will, of course, determine the process selected.

Combined Municipal-Industrial Systems

In addressing all forms of pollution in an areawide plan, a fundamental issue concerns whether the industrial wastes should be treated separately or served by the municipal system. In resolving this issue, each industry should be evaluated independently in terms of its interest in and availability of service by the municipal system, the quantity and characteristics of its waste, and the extent of any pretreatment required.

Specific questions to bear in mind:

1. Is the industry interested in having its wastes treated by the municipal system?

2. What is the quantity and nature of the industry's discharges?

3. Are in-plant changes to minimize waste possible?

4. What pretreatment requirements are necessary before discharge into the municipal system?

5. Has water recycling been investigated?

6. Has product recovery been investigated?

Industrial economics regard water as a process input and treatment

of existing discharges is considered as only one option for pollution abatement. Process changes, perhaps effected in answer to pretreatment requirements, are another alternative. Water reuse and by-product recovery within the plant are some beneficial possibilities, along with recycling or in-plant modifications in lieu of pretreatment and discharge to the municipal system.

Central to resolution of the issue of creating a joint municipal-industrial system is the question: Has the analysis of alternatives included examination of the total pollution abatement costs associated with separate, partially integrated, and totally integrated municipal-industrial systems?

From a cost-effective viewpoint, the goal of pollution control is to accomplish abatement at a minimum total cost. Therefore, the strategy to be followed must consider all costs within the planning area. Often joint municipal-industrial systems will result in minimizing public, as well as private, costs because of the economies of scale in constructing and operating larger facilities.

Individual vs. Central Treatment Systems

For scattered, outlying settlements and small, isolated communities, the opportunities may not be available to join into a

regional or metropolitan wastewater system. Generally, their options for controlling wastewater sources are limited. If the community is currently sewered and growth is occurring, the local jurisdiction may upgrade or expand the present treatment facilities, extend service to new users, or combine these actions. If not sewered, the community may develop sewers and treatment facilities or rely on the existing facilities (presumably on-site septic tanks and soil absorption systems.)

A low-density community with limited or no prospects for growth, and which is sewered by individual units, generally has little reason to develop a centralized sewerage system if the present facilities are not causing a water pollution problem or creating a significant nuisance. Even if these problems do exist, perhaps they could be best solved by a community-operated program of maintenance or reinstallation of drain fields. However, at the same time, all communities must guard against groundwater contamination from septic tanks and otherwise ensure that water quality standards can be achieved and maintained.

If a centralized system is needed, none of the options available to such small communities are particularly attractive because of the high unit costs for providing a collection system and treatment facility for serving small quantities of wastewater. In addition to costs,

comparison of treatment processes should be based in large part upon their reliability in continually achieving design treatment levels to protect the receiving waters.

The following questions are designed to determine if soil absorption units or a centralized treatment system is needed.

1. Are there problems associated with continuing to add septic tanks within the service area?

2. Can these problems be solved with a community-operated program of renovation, proper design and reinstallation of drain fields, and scheduled maintenance?

3. Is groundwater protected? Recent experience with septic tanks indicates that soil permeability tests are more important than percolation tests in determining suitability. Revised criteria for septic tank and drain field sizing may alleviate the problem of "creeping failure."

4. Are dwellings clustered in the service area? If so, fewer but larger septic tank facilities serving cluster developments would reduce costs compared to individual units. Larger units may also justify a central sludge facility. (See Mitre Corporation report entitled Selected Economic and Environmental Aspects of Individual Wastewater Treatment Systems, March 1972.)

5. What are the advantages, if any, in installing sewers and a central treatment plant in a community not now sewered in terms of meeting water quality standards, health and other environmental impacts, overall community goals, and capital-operating costs?

6. Can a small community operate a relatively complex sewage treatment plant at an acceptable level of effectiveness and reliability?

IV. Selecting the Treatment Process

Determining and selecting the optimum treatment process for a given site involves balancing considerations of cost, performance reliability, opportunities for reuse and recycling, and mode of disposal of the treatment facility effluent and sludge product. Wastewater that is not recycled within the system is available for replenishment of either the groundwater or surface water sources or for meeting local needs for irrigation. The type of treatment process selected--whether physical, biological, or chemical, or some combination of these--will depend upon the cost-effective solution of the above considerations.

Upgrading the Present Facility

One means of meeting both the short and long term demand for wastewater treatment is to upgrade or expand the existing facilities.

The possibility of expanding existing wastewater treatment facilities should always be considered in developing a regional system. Expansion of such facilities may be particularly attractive to minimize the impact of a system upon the local environment. Generally, existing urban development in the vicinity of present treatment has adjusted to the facility and the expansion of this facility might not cause as much of an impact as developing new facilities at different locations.

Upgrading existing treatment facilities may be economically accomplished by merely using available facilities more efficiently. Some examples might be replacing filter stones with synthetic filter media, pure oxygen aeration in the activated sludge process, chemical addition to increase sedimentation efficiencies, the conversion of a low-rate trickling filter to high rate application, and use of flow equalization facilities. In some instances, upgrading may provide a short-term solution to an existing water quality problem while a longer-term solution is being developed. In other instances, upgrading of existing facilities may also provide a long-term solution if influent flows to the plant are limited by local zoning, other controls on growth, or diversion of excess flows to other treatment plants. More detailed information on upgrading is available in an EPA design manual entitled Upgrading of Existing Wastewater Treatment Plants (1972).

Questions pertaining to the upgrading or expansion of treatment plants:

1. Does an immediate water quality problem exist and does the plan include an interim solution?

2. Can the problem be met during the interim period through upgrading of existing facilities?

3. Do the alternative solutions incorporate upgrading or expanding the existing treatment facilities?

Reliability and Flexibility

The reliability of a wastewater treatment project or system is determined by two major measurements: (1) Its ability to perform its designed function over a range of influent conditions within the system, and (2) Its ability to contribute as intended to the achievement of water quality goals and standards. The first point relates to the reliability of the design and operation of a specific facility as discussed in the Guidelines for Design, Operation and Maintenance (EPA). The second point relates to the adequacy of performance over time. Engineering excellence in facility design and operation cannot assure reliability in maintaining the water quality standards if performance requirements are not well defined by a management plan for the basin and the metro/regional area.

In evaluating a series of alternatives for a wastewater system or for individual projects, the EPA Design Guidelines emphasize the need for continuous reliability of performance. Different systems, treatment processes, size of facilities, modes of effluent disposal, and other related factors can result in different levels of reliability in protecting water quality. These different levels of reliability should be considered either analytically or subjectively in a comparison of alternative solutions.

To determine performance reliability the planner should ask:

1. Are the facility performance requirements necessary to meet water quality standards and other defined goals clearly specified for the planning period?

2. Does the comparison of alternative solutions recognize differences in reliability of performance among the alternatives?

3. Were these differences considered in selecting the recommended solution?

The quality of flexibility is as necessary as reliability in planning for implementing timely changes in a treatment system. To include flexibility in his plan, the planner should determine:

1. If economic and social factors and goals change, can in-stream disposal be readily converted to land-based disposal?

2. Do the treatment sites include adequate space or allow additional land acquisition to permit process expansions or changes?

The EPA Design Guidelines address the need for flexibility in a treatment facility to provide for efficiency in operation and maintenance. In addition, consideration must be given to the possible requirement for major changes in the system responsive to varying overall objectives. Social objectives for water quality management, and economic and

technological conditions have changed in the past and will undoubtedly change in the future.

Reuse of Wastewater

In many parts of the country--particularly the western states, metropolitan areas, and coastal zones--serious water quantity shortages exist or are anticipated. In these areas, demands for water are increasing for such uses as agricultural irrigation, industrial processing and cooling, parks and recreation developments, and groundwater replenishment. Furthermore, high levels of wastewater treatment are usually required in these areas to meet the water quality standards or goals. In many instances the increasing use demands on a decreasing water supply justify wastewater reuse and the added costs of further treatment, if required, and conveyance to the point of need.

Some planning questions pertinent to wastewater reuse:

1. Are water resource problems identified?

2. Is there a limited water resource in the area, and is this reflected in a demand or potential demand for wastewater reuse?

3. Are reuse alternatives considered?

4. Are the added costs of treatment and conveyance facilities shown?

5. Are such costs competitive with alternative sources of water supply in the area for these uses?

6. Are there advantages to meeting water quality standards by reuse rather than discharge directly to a receiving stream?

7. Conversely, would reuse lead to water deficiencies in the receiving stream?

Water Disposal vs. Land Disposal of Effluent

Closely aligned to the issue of wastewater recycling is the issue of whether the treated effluent should be disposed of in water or on land. This issue assumes greater importance in the same areas where recycling needs are the greatest--namely arid regions, urban centers, and coastal zones.

Land disposal of wastes is usually dictated by a combination of economic and water quality/quantity factors. This is particularly true for irrigation alternatives where the economic value of water can offset possible additional costs for water conveyance to the use point and for more advanced treatment, if required. Other forms of land disposal may be warranted to replenish groundwater supplies as well as to meet in-stream water quality standards. Depending upon local conditions and the quality of the effluent, such land disposal can be accomplished through intensive spray irrigation, surface infiltration ponds, and recharge wells. Each technique would utilize the soil

for filtering and further purification. But, care must be taken to avoid groundwater contamination with disease organisms or toxic elements; also, soil contamination with grease, oil or heavy metals.

In evaluating effluent disposal at inland locations, the impact of such disposal upon the hydrological system of the river basin encompassing the study area is important. Land disposal would affect flow levels in receiving streams especially during low-flow periods, depending upon the location and type of disposal techniques used. Many land disposal methods impose additional evapotranspiration losses on the hydrologic system--losses which would not have occurred from discharging directly to a receiving stream. This is particularly true where wastewater is used for irrigation. The specific effects of such losses upon low-flow periods would vary among basins depending upon localized hydrologic, geologic, and climatic conditions, but this loss factor should be recognized when considering large-scale land disposal alternatives.

Specific questions pertinent to land disposal of effluent:

1. Could the groundwater depletion problem be better solved through curtailment of withdrawals in favor of alternative water supply sources?

2. For irrigation uses to be publicly developed, have all costs

associated with land acquisition and relocations according to the Relocations Act been included, together with evaluations of expected economic returns from such irrigation?

3. Could this land be better used for other purposes?

4. In lieu of publicly owned irrigation developments, has the option of selling the wastewater to private irrigation interests also been explored?

5. If the recommended solution is an in-stream disposal of the effluent, can it be readily converted to a land-use disposal should economic and social desires change?

Ultimate Disposal of Liquid, Sludge, and Other Wastes

Whatever wastewater treatment strategy is implemented, it will result in sludge, debris, and liquid effluents. The final disposal of these products must be accomplished within stringent environmental limits. This limitation should be recognized throughout the system and process selection phases.

The evaluation of land versus a water-based disposal system must consider the assimilative waste capacity of the resource. Frequently the assimilative capacity of a stream is substantially increased at a downstream location at a point below its confluence with a major tributary. Transmission of the effluent to that location could permit

a lesser degree of treatment. Likewise, extension of an ocean outfall into an area with a prevailing outward current and increased depth would lessen the impact upon the receiving waters. The disposal of treated sludge involves similarly interrelated economic and environmental factors.

Questions pertaining to the ultimate disposal of treatment materials:

1. Have alternative locations and lengths of effluent outfalls been considered?

2. Has a cost advantage been gained by outfall design or location by virtue of added dilution?

3. Would transport of the treated effluent out of the immediate area or hydrologic basin be a more economical alternative, presuming inadequate streamflows at the proposed treatment plant site?

4. If sludge, debris and other wastes are to be transported out of the immediate area or river basin, have all possible environmental and legal problems been investigated?

5. What are the costs of various methods of processing and disposal?

6. What are the environmental impacts of those methods?

7. Have alternative locations for disposal of the treatment product (processed sludge) been identified?

8. Is there an economic market for it?

9. If incineration is contemplated, what impact will this have on air quality?

V. Scheduling Construction of Facilities

The wastewater flow projections discussed in Chapter II define the time-related quantities of wastewater to be treated within the planning area. The means of selecting a cost-effective wastewater systems configuration for treating these flows has also been discussed. Those selection procedures result in a system which defines the general location and projected demand curve for each facility within the system.

Determining schedules for sewering the service area and constructing the treatment facilities must also be based on cost-effectiveness criteria. This involves a tradeoff between two basic approaches: One is to construct smaller facilities initially to meet short-term demand, and schedule subsequent modular expansion and upgrading as needed over time. The second is to construct a larger, total system with substantial reserve capacity to meet projected demand well into the future. It should be emphasized that use of modulated construction with relatively short design periods does not conflict with nor preclude longer planning periods.

The following questions are intended to determine whether the plan or project under review was based upon adequate consideration of the relationship between overall facility costs (both capital and operation) and facility design period.

1. Is the estimated time for the plant or interceptors to reach full capacity reasonable in the light of estimated growth rates and area characteristics? (See Appendix B for typical population growth rates.)

2. Does the plan consider modulated (stepped) construction of individual components?

3. Are the growth rates such that modulated construction would be cost effective?

Short Design Periods

The following factors suggest the use of relatively short design periods in estimating future capacity.

1. The inherent uncertainty in long-term forecasting of wastewater quantities, especially for areas undergoing rapid changes in population and economic activities;

2. The possibility of phasing construction which could result in overall savings in debt service and operating costs;

3. The possibility of utilizing new technology when it becomes available;

4. The difficulty of achieving design removal efficiencies when the capacity of a plant substantially exceeds the wastewater volume treated; and

5. Changes in social goals which may significantly alter future waste management objectives.

These considerations suggest that the capacity of a system should extend only a short timeframe ahead of the projected wastewater demand to avoid large amounts of under-utilized investments in the system and to keep options open for flexibility in the future. This is particularly important in systems which must meet a rapidly expanding wastewater treatment demand.

Long Design Periods

The four major factors which have encouraged local communities to favor the use of larger initial capacities in the wastewater system to meet projected needs over a longer design period are these:

1. Economies of scale in constructing larger interceptors and wastewater treatment facilities;

2. High inflation rates in wastewater facilities construction costs;

3. Uncertainties in the future availability of Federal and state construction funds; and

4. Increased opportunities for future community development; i.e., removal of waste treatment constraints on new construction in the building and industrial sectors.

The economies of scale must be considered in the alternative analysis and will be compared with increased future costs, discounted to present worth, in meeting future needs. Community development

should be evaluated in the overall community-planned program, and wastewater facilities are one of the services needed to accommodate the community development desired.

The advantages and disadvantages of short vs. longer design periods, or modular construction vs. contruction of reserve capacity in a system, should be carefully weighed and balanced. And, the planner should also consider the often not so obvious broader environmental questions. For example, would building large over-capacity into sewer lines and treatment plants artificially stimulate intensive community development? This is a special danger where sould land-use planning and zoning do not exist or are not enforced.

Financing

The interplay between the cost factors in meeting both short and long-term needs is very important. The construction cost inflation factor may well encourage local decisionmakers to choose a large reserve capacity system. The substantial increase in sewer construction during the past five years, stimulated by steadily increasing Federal and state funding, has resulted in escalating costs and lengthening construction schedules. With increased funding likely in the future, it is reasonable to postulate a near-term continuation of inflation in

construction costs. The physical ability of construction companies will be heavily taxed to meet the demand for wastewater facilities, but on the other hand, construction capacity should increase as funding increases. Projecting future inflation is hazardous, but it is reasonable to anticipate a construction capacity adequate to meet construction needs within the next five years.

Another financing factor is the relationship of inflation expectation and municipal bond rates. From the local viewpoint the cost of financing (debt service) is a decision criteria. Since inflation and bonding rates (interest) are interrelated, high inflation rates usually mean higher bonding rates. In making its decision the municipality must recognize that it may have to pay an increased debt service resulting from anticipated inflation.

Treatment Plants

The relationship between maximum required capacity projected at the end of the planning period and staged construction of treatment facilities should be explored, especially in large plants. In many cases, an economic advantage is gained by determining the facilities needed to serve area urban development anticipated at the end of the planning period and by scheduling a sequence of modular developments of these facilities to assure adequate capacity throughout the planning period. Operational units would thus be placed on line as modules so that the

capacity requirements are always met while at the same time avoiding over capacity. The module size should be determined by analyzing capital, and operating and maintenance costs for a range of conceivable module sizes and design periods. The minimum time for design and construction of a module and the type of projected growth place a lower limit on the projection period for determining module size. Five years measured from the date of anticipated completion of construction is a suggested lower limit. This is judged to be the minimum time required to design, fund, and construct a module.

In general, because of the uncertainty attached to long-term population projections and the problems of planning in a dynamic environment, the projection period for a module should be inversely related to expected demand growth. For a community expecting virtually no additional treatment requirements, a projection period of up to 25 years may be acceptable for facilities. In this case the module projection period may coincide with the planning period. For a community which expects to grow significantly, a module projection period of more than ten to fifteen years is usually imprudent. Similarly, module design lives should be inversely related to the level of interest rates.

Interceptor Sewers

Staged development of interceptor sewers involves two different concepts--the modular development of a given line, and the extension of

lines as the service area grows. Because of the nature of its construction, a given interceptor sewer is not as readily adapted to modular construction as a treatment plant.

In an urban area with a high rate of growth, however, staged development of an interceptor sewer including the development of parallel lines should be considered and may be justified in terms of deferring investments until needed, protecting against the uncertainty of long-term wastewater projections, and providing the flexibility to adjust to unforeseen changes in growth patterns within the urban area. This is particularly true during periods of high interest rates because a substantial portion of interceptor costs result from debt service. Furthermore, the existence of a large unused capacity in an interceptor line can, in the absence of a sound land-use plan and zoning, induce intensive development inconsistent with good land use practices and the public desire.

For areas of high anticipated growth, design lives of interceptor sewers of more than 20 to 25 years may not be prudent. Parallel lines need not be constructed on the same right-of-way. Alternate routes can be selected for future development. If plans call for the development of two or more parallel lines within a right-of-way, adequate safeguards will be required to control other possible uses of the right-of-way.

Review Questions for Planning
Municipal Wastewater Treatment Facilities

Projecting Wastewater Flows

Existing Flows

Review and evaluation of the existing wastewater flows should provide answers to several questions, including:

1. Is there excessive infiltration into the system?
2. Are there illegal storm water connections, and is so, what is being done about them?
3. Are sewer ordinances adequate and are they enforced?
4. Are reported waste flows reasonable and are they based on actual in-plant measurements?
5. Are reported per capita waste loadings representative?
6. How were they determined and is the method defensible?

Population

In projecting population growth, these questions should be answered:

1. Are projected population growth rates realistic?
2. What is their basis?
3. Do the figures distinguish between total population and sewered population?
4. How does the projection compare with existing data?
5. If discrepancies exist, what caused them?
6. What, if any, land use constraints were considered in the population projections?

Preceding page blank

Industry

In projecting future wastewater flows planners should consider questions concerning industrial connections to the municipal system, such as:

1. Do already connected industrial sources expect their discharges to increase, decrease, or remain constant?

2. Will the nature of discharges from connected industries change?

3. What are the prospects of unconnected industries hooking up with the municipal system in the future?

4. What are the prospects of new industries locating in the area, and what will this mean for industrial service as well as increased domestic service?

Assembling a Wastewater Systems Configuration

During the system selection process, the planner examines these questions:

1. Has upgrading of existing facilities been considered? What are the advantages and disadvantages?

2. Has regionalization of facilities been considered?

3. Has a combined municipal-industrial waste treatment system been considered?

4. Has recycling been considered?

5. Has a soil disposal system been considered?

6. What legal and other institutional methods of regulating waste discharges, reducing collection costs, etc. were considered?

7. Are cost estimates presented for all feasible alternatives, and are they consistent with generalized cost curves for the area?

Combined Municipal-Industrial Systems

The issue of whether or not industrial wastes should be treated separately or served by the municipal system turns upon how the following questions are answered:

1. Is the industry interested in having its wastes treated by the municipal system?

2. What is the quantity and nature of the industry's discharges?

3. Are in-plant changes to minimize waste possible?

4. What pretreatment requirements are necessary before discharge into the municipal system?

5. Has water recycling been investigated?

6. Has product recovery been investigated?

7. Has the analysis of alternatives included examination of the total pollution abatement costs associated with separate, partially integrated, and totally integrated municipal-industrial systems?

Individual vs. Central Treatment Systems

The following questions are designed to determine if soil absorption units or a centralized treatment system is needed:

1. Are there problems associated with continuing to add septic tanks within the service area?

2. Can these problems be solved with a community-operated program of renovation, proper design and reinstallation of drain fields, and scheduled maintenance?

3. Is groundwater protected?

4. Are dwellings clustered in the service area?

5. What are the advantages, if any, in installing sewers and a central treatment plant in a community not now sewered in terms of meeting water quality standards, health and other environmental impacts, overall community goals, and capital-operating costs?

6. Can a small community operate a relatively complex sewage treatment plant at an acceptable level of effectiveness and reliability?

Selecting the Treatment Process

Upgrading the Present Facility

Questions pertaining to the upgrading or expansion of treatment plants:

1. Does an immediate water quality problem exist and does the plan include an interim solution?

2. Can the problem be met during the interim period through upgrading of existing facilities?

3. Do the alternative solutions incorporate upgrading or expanding the existing treatment facilities?

Reliability and Flexibility

To determine performance reliability the planner should ask:

1. Are the facility performance requirements necessary to meet water quality standards and other defined goals clearly specified for the planning period?

2. Does the comparison of alternative solutions recognize differences in reliability of performance among the alternatives?

3. Were these differences considered in selecting the recommended solution?

To include flexibility in his plan, the planner should determine:

1. If economic and social factors and goals change, can in-stream disposal be readily converted to land-based disposal?

2. Do the treatment sites include adequate space or allow additional land acquisition to permit process expansions or changes?

Reuse of Wastewater

Some planning questions pertinent to wastewater reuse:

1. Are water resource problems identified?
2. Is there a limited water resource in the area, and is this reflected in a demand or potential demand for wastewater reuse?
3. Are reuse alternatives considered?
4. Are the added costs of treatment and conveyance facilities shown?
5. Are such costs competitive with alternative sources of water supply in the area for these uses?
6. Are there advantages to meeting water quality standards by reuse rather than discharge directly to a receiving stream?
7. Conversely, would reuse lead to water deficiencies in the receiving stream?

Water Disposal vs. Land Disposal of Effluent

Questions pertinent to land disposal of effluent:

1. Could the groundwater depletion problem be better solved through curtailment of withdrawals in favor of alternative water supply sources?
2. For irrigation uses to be publicly developed, have all costs associated with land acquisition and relocations according to the Relocations Act been included, together with evaluations of expected economic returns from such irrigation?
3. Could this land be better used for other purposes?
4. In lieu of publicly owned irrigation developments, has the option of selling the wastewater to private irrigation interests also been explored?
5. If the recommended solution is an in-stream disposal of the effluent, can it be readily converted to a land-use disposal should economic and social desires change?

Ultimate Disposal of Liquid, Sludge, and Other Wastes

Questions pertaining to the ultimate disposal of treatment materials:

1. Have alternative locations and lengths of effluent outfalls been considered?

2. Has a cost advantage been gained by outfall design or location by virtue of added dilution?

3. Would transport of the treated effluent out of the immediate area or hydrologic basin be a more economical alternative, presuming inadequate streamflows at the proposed treatment plant site?

4. If sludge, debris and other wastes are to be transported out of the immediate area or river basin, have all possible environmental and legal problems been investigated?

5. What are the costs of various methods of processing and disposal?

6. What are the environmental impacts of those methods?

7. Have alternative locations for disposal of the treatment product (processed sludge) been identified?

8. Is there an economic market for it?

9. If incineration is contemplated, what impact will this have on air quality?

Scheduling Construction of Facilities

The following questions are intended to determine whether the plan or project under review was based upon adequate consideration of the relationship between overall facility costs (both capital and operation) and facility design period:

1. Is the estimated time for the plant or interceptors to reach full capacity reasonable in the light of estimated growth rates and area characteristics?

2. Does the plan consider modulated (stepped) construction of individual components?

3. Are the growth rates such that modulated construction would be cost effective?

Summary of National Population Trends

General

Population data contained in this Appendix may be useful in evaluating population and associated wastewater flow projections of a particular planning area or project service area. The data provide a measure of recent growth experience for regions, States, and localities which may be compared to short-term growth rates for a a particular area. The use of this data should not be considered valid for long-term trends in that such growth would likely be influenced by changing economic and demographic conditions of the area. Many regions, States, and areas can be expected to experience a long-term reduction in population growth rates similar to that anticipated for the entire nation. This decline should be factored into the long-term projections for a particular area, if appropriate.

Metropolitan Areas

Table I contains the growth rates that occurred during the 1960's for each of the States. Similarly, census data for Standard Metropolitan Service Areas (SMSA's) for that decade are contained in Table II. The growth rates shown for both of these tables represent an average annual arithmetic change in percent for the ten-year period as related to the 1960 population.

Preceding page blank

The Environmental Protection Agency, in cooperation with the Office of Business Economics, U.S. Department of Commerce, is preparing population projections for the SMSA's through year 2000 which should provide guidance for the review of long-term projections of a metropolitan area.

Non-Metropolitan Areas

For communities in counties which are not part of SMSA's, population trends for the 1960 decade have been evaluated according to the size of the principal municipality within each county. Figures 1-10 show a breakdown in growth trends for non-SMSA counties for each of the ten EPA regions. These histograms are subdivided into three groups based on the population of the largest municipality within the county of less than 10,000; 10,000 to 25,000; and 25,000 to 50,000. Each histogram bar indicates the percentage of the counties that fall within a specified range of annual population change. Thus, for each histogram, the percentages add up to 100. In addition to the distribution, the range and median of the growth rates are given for each of the population groups.

A comparison of these histograms in Figure 11 shows that growth rates in non-SMSA areas are generally low (or negative), differ considerably among regions, and are substantially lower than for SMSA centers. For example, the median annual growth rate for all non-SMSA counties in the Denver Region was between -0.5 to -1.0 percent as compared to

1.5 to 2.0 percent in the San Francisco Region. Also, within a given region the growth rates may differ considerably among the three groups (such as the Denver Region) while other regions are experiencing little differences among these groups (such as Chicago).

These graphs are intended to be used in screening population projections contained in plans.

Table 1.--1970 POPULATION BY STATE

State	Resident Population (1)	Population Abroad[1] (2)	Population used as basis for apportionment (3) = (1) + (2)
United States.	203,184,772	1,580,998	[2] 204,002,799
Alabama	3,444,165	31,720	3,475,885
Alaska	302,173	1,894	304,067
Arizona	1,772,482	15,138	1,787,620
Arkansas	1,923,295	19,008	1,942,303
California	19,953,134	145,729	20,098,863
Colorado	2,207,259	19,512	2,226,771
Connecticut	3,032,217	18,476	3,050,693
Delaware	548,104	3,824	551,928
District of Columbia	756,510	6,461	-
Florida	6,789,443	66,259	6,855,702
Georgia	4,589,575	37,731	4,627,306
Hawaii	769,913	14,988	784,901
Idaho	713,008	6,913	719,921
Illinois	11,113,976	70,344	11,184,320
Indiana	5,193,669	34,487	5,228,156
Iowa	2,825,041	21,879	2,846,920
Kansas	2,249,071	16,775	2,265,846
Kentucky	3,219,311	27,170	3,246,481
Louisiana	3,643,180	28,828	3,672,008
Maine	993,663	12,657	1,006,320
Maryland	3,922,399	31,299	3,953,698
Massachusetts	5,689,170	37,506	5,726,676
Michigan	8,875,083	62,113	8,937,196
Minnesota	3,805,069	28,104	3,833,173
Mississippi	2,216,912	16,936	2,233,848
Missouri	4,677,399	40,635	4,718,034
Montana	694,409	7,164	701,573
Nebraska	1,483,791	13,029	1,496,820
Nevada	488,738	3,658	492,396
New Hampshire	737,681	8,603	746,284
New Jersey	7,168,164	39,871	7,208,035
New Mexico	1,016,000	10,664	1,026,664
New York	18,190,740	96,789	18,287,529
North Carolina	5,082,059	43,171	5,125,230
North Dakota	617,761	6,420	624,181
Ohio	10,652,017	78,183	10,730,200
Oklahoma	2,559,253	26,233	2,585,486
Oregon	2,091,385	19,425	2,110,810
Pennsylvania	11,793,909	90,405	11,884,314
Rhode Island	949,723	8,075	957,798
South Carolina	2,590,516	26,804	2,617,320
South Dakota	666,257	6,990	673,247
Tennessee	3,924,164	36,896	3,961,060
Texas	11,196,730	102,057	11,298,787
Utah	1,059,273	8,537	1,067,810
Vermont	444,732	3,595	448,327
Virginia	4,648,494	42,248	4,690,742
Washington	3,409,169	34,318	3,443,487
West Virginia	1,744,237	19,094	1,763,331
Wisconsin	4,417,933	29,080	4,447,013
Wyoming	332,416	3,303	335,719

1/ Includes: (a) Members of the Armed Forces; (b) Civilian employees of any Federal department or agency who are citizens of the United States or who have a home State; (c) Spouses and children who are living abroad with persons classified in groups (a) and (b); (d) Other relatives living abroad with persons in groups (a) and (b) who are citizens of the United States or have a home State.

2/ Excludes the District of Columbia. The total including the District of Columbia is 204,765,770.

TABLE 2 - POPULATION CHANGE
STANDARD METROPOLITAN STATISTICAL AREAS
1960-70

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
ABILENE, TEX.	114.0	120.4	-6.4	-0.5
AKRON, OHIO	679.2	605.4	73.8	1.2
ALBANY, GA.	89.6	75.7	13.9	1.8
ALBANY-SCHENECTADY-TROY, N.Y.	720.8	657.5	63.3	1.0
ALBUQUERQUE, N.M.	315.8	262.2	53.6	2.0
ALLENTOWN-BETHLEHEM-EASTON, PA.-N.J.	543.5	492.2	51.3	1.0
ALTOONA, PA.	135.4	137.3	-1.9	-0.1
AMARILLO, TEX.	144.4	149.5	-5.1	-0.3
ANAHEIM-SANTA ANA-GARDEN GROVE, CALIF.	1420.4	703.9	716.5	10.2
ANDERSON, IND.	138.5	125.8	12.7	1.0
ANN ARBOR, MICH.	234.1	172.4	61.7	3.6
APPLETON-OSHKOSH, WIS.	276.9	232.0	44.9	1.9
AUGUSTA, GA. -S.C.	253.5	216.6	36.9	1.7
AUSTIN, TEX.	295.5	212.1	83.4	3.9
ASHEVILLE, NC.	145.1	130.1	15.0	1.2
ATLANTA, GA.	1390.2	1017.2	373.0	3.7
ATLANTIC CITY, N.J.	175.0	160.9	14.1	0.9
BAKERSFIELD, CALIF.	329.2	292.0	37.2	1.3
BALTIMORE, MD.	2070.7	1803.7	267.0	1.5
BATON ROUGE, LA.	285.2	230.1	55.1	2.4
BAY CITY, MICH.	117.3	107.0	10.3	1.0
BEAUMONT-PORT ARTHUR-ORANGE, TEX.	315.9	306.0	9.9	0.3
BILLINGS, MONT.	87.4	79.0	8.4	1.1
BILOXI-GULFPORT, MISS.	134.6	119.5	15.1	1.3
BINGHAMTON, N.Y. -PA.	302.7	283.6	19.1	0.7
BIRMINGHAM, ALA.	739.3	721.2	18.1	0.3
BLOOMINGTON,-NORMAL, ILL.	104.4	83.9	20.5	2.4
BOIS CITY, IOWA	112.2	93.5	18.7	2.0
BOSTON, MASS.	2753.7	2595.5	158.2	0.6
BRIDGEPORT, CONN.	389.2	338.0	51.2	1.5
BRISTOL, CONN.	65.8	54.5	11.3	2.1
BROCKTON, MASS.	189.8	149.5	40.3	2.7
BROWNSVILLE-HARLINGEN-SAN BENITO,TEX.	140.4	151.1	-10.7	-0.7
BRYAN-COLLEGE STATION, TEX.	58.0	44.9	13.1	2.9
BUFFALO, N.Y.	1349.2	1306.9	42.3	0.3
CANTON, OHIO	372.2	340.3	31.9	0.9
CEDAR RAPIDS, IOWA	163.2	136.9	26.3	1.9

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
CHAMPAIGN-URBANA, ILL.	163.3	132.4	30.9	2.3
CHARLESTON, S.C.	303.9	254.6	49.3	1.9
CHARLESTON, W. VA.	229.5	252.9	-23.4	-0.9
CHARLOTTE, N.C.	409.4	316.8	92.6	2.9
CHATTANOOGA, TENN.-GA.	304.9	283.2	21.7	0.8
CHICAGO, ILL.	6978.9	6220.9	758.0	1.2
CINCINNATI, OHIO	1384.9	1268.5	116.4	0.9
CLEVELAND, OHIO	2064.2	1090.5	154.7	0.8
COLORADO SPRINGS, COL.	236.0	143.7	92.3	6.4
COLUMBIA, S.C.	322.9	260.8	62.1	6.4
COLUMBIA, MO.	80.9	55.2	25.7	2.4
COLUMBUS, GA.-ALA.	238.6	218.0	20.6	4.7
COLUMBUS, OHIO	916.2	754.9	161.3	0.9
CORPUS CHRISTI, TEX.	284.8	266.6	18.2	2.1
DALLAS,TEXAS	1555.9	1119.4	436.5	0.7
DANBURY, CONN.	78.4	54.3	24.1	3.9
DAVENPORT-ROCK ISLAND-MOLINE,IOWA-ILL.	362.6	319.4	43.2	4.4
DAYTON, OHIO	850.3	727.1	123.2	1.4
DECATUR, ILL.	125.0	118.3	6.7	1.7
DENVER, COLO.	1227.5	929.4	298.1	0.6
DES MOINES, IOWA	286.1	266.3	19.8	2.2
DETROIT, MICH.	4199.0	3762.4	436.6	0.7
DUBUQUE, IOWA	90.6	80.0	10.6	1.2
DULUTH-SUPERIOR, MINN-WIS.	265.4	276.6	-11.2	1.3
DURHAM, N.C.	190.4	155.0	35.4	-0.4
EL PASO, TEXAS	359.3	314.1	45.2	2.3
ERIE, PA.	263.7	250.7	13.0	1.4
EUGENE, OREGON	213.4	162.9	50.5	0.5
EVANSVILLE, IND.-KY.	232.8	222.9	9.9	3.1
FALL RIVER, MASS. -R.I.	150.5	138.2	12.3	0.4
FARGO-MOORHEAD, N.D. -MINN.	120.2	106.0	14.2	0.9
FAYETTEVILLE,N.C.	212.0	148.4	63.6	1.3
FITCHBURG-LEOMINSTER, MASS.	97.2	90.2	7.0	4.3
FLINT,MICH	496.7	416.2	80.5	0.8
FORT SMITH, ARK.-OKLA.	160.4	135.1	25.3	1.9
FORT WAYNE, IND.	280.5	232.2	48.3	1.9
FORT WORTH, TEXAS	762.1	573.2	188.9	2.1
FRESNO, CALIF.	413.1	365.9	47.2	3.3
				1.3

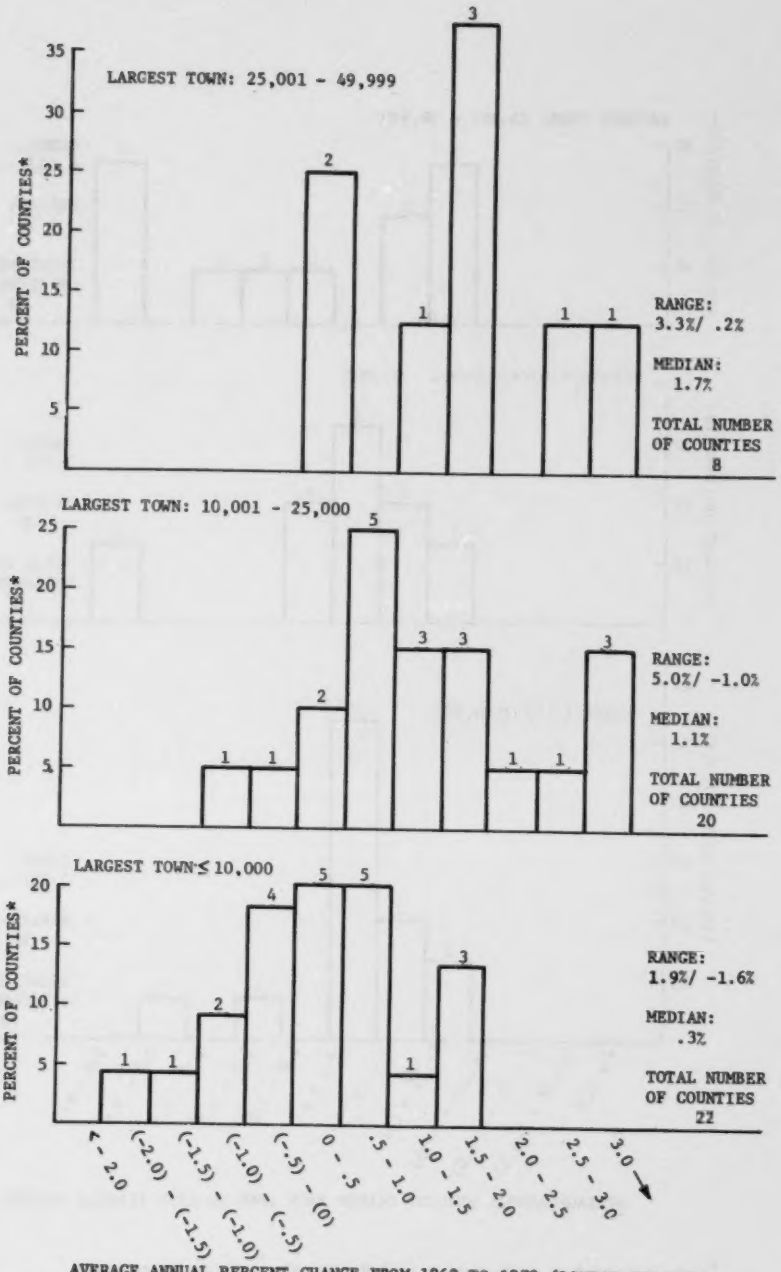
	POP 70	POP 60	CHG 60-70	ANN PCT CHG
FT. LAUDERDALE-HOLLYWOOD, FLA.	620.1	333.9	286.2	8.6
GADSDEN, ALA.	94.1	97.0	-2.9	-0.3
GAINESVILLE, FLA.	104.8	74.1	30.7	4.1
GALVESTON-TEXAS CITY, TEX.	169.8	140.4	29.4	2.1
GARY-HAMMOND-EAST CHICAGO, IND.	633.4	573.5	59.9	1.0
GRAND RAPIDS, MICH.	539.2	461.9	77.3	1.7
GREAT FALLS, MONT.	81.8	73.4	8.4	1.1
GREEN BAY, WIS.	158.2	125.1	33.1	2.6
GREENSBORO-WINSTON-SALEM-HIGH POINT,NC.	603.9	520.2	83.7	1.6
GREENVILLE, S.C.	299.5	255.8	43.7	1.7
HAMILTON-MIDDLETOWN, OHIO	226.2	199.1	27.1	1.4
HARRISBURG, PA.	410.6	371.7	38.9	1.0
HARTFORD, CONN.	663.9	549.2	114.7	2.1
HONOLULU, HAWAII	630.5	500.4	130.1	2.6
HOUSTON, TEXAS	1985.0	1418.3	566.7	4.0
HUNTINGTON-ASHLAND, W. VA.-KY.-OHIO	253.7	254.8	-1.1	-0.0
HUNTSVILLE, ALA.	228.2	153.9	74.3	4.8
INDIANAPOLIS, IND.	1109.9	944.5	165.4	1.8
JERSEY CITY, N.J.	609.3	610.7	-1.4	-0.0
JACKSON, MICH.	143.3	132.0	11.3	0.9
JACKSON, MISS.	258.9	221.4	37.5	1.7
JACKSONVILLE, FLA.	528.9	455.4	73.5	1.6
JOHNSTOWN, PA.	262.8	280.7	-17.9	-0.6
KALAMAZOO, MICH.	201.6	169.7	31.9	1.9
KANSAS CITY, MO.-KAN.	1256.6	1092.5	164.1	1.5
KENOSHA, WIS.	117.9	100.6	17.3	1.7
KNOXVILLE, TENN.	400.3	368.1	32.2	0.9
LA CROSSE, WIS.	80.5	72.5	8.0	1.1
LAFAYETTE, LA.	111.7	84.7	27.0	3.2
LAFAYETTE, W. LAFAYETTE, IND.	109.4	89.1	20.3	2.3
LAKE CHARLES, LA.	145.4	145.5	-0.1	-0.0
LANCASTER, PA.	319.7	278.4	41.3	1.5
LANSING, MICH.	378.4	298.9	79.5	2.7
LAREDO, TEXAS	72.9	64.8	8.1	1.3
LAS VEGAS, NEV.	273.3	127.0	146.3	11.5
LAWRENCE-HAVERHILL, MASS.-N.H.	232.4	199.1	33.3	1.7
LAWTON, OKLA.	108.1	90.8	17.3	1.9
LEWISTON-AUBURN, ME.	72.5	70.3	2.2	0.3
LEXINGTON, KY.	174.3	131.9	42.4	3.2
LIMA, OHIO	171.5	160.9	10.6	0.7

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
LINCOLN, NEBR.	168.0	155.3	12.7	0.8
LITTLE ROCK-NORTH LITTLE ROCK, ARK	323.3	271.9	51.4	1.9
LORAIN-ELYRIA, OHIO	256.8	217.5	39.3	1.8
LOS ANGELES-LONG BEACH, CALIF.	7032.1	6038.8	993.3	1.6
LOUISVILLE, KY.-IND.	826.6	725.1	101.5	1.4
LOWELL, MASS.	212.9	164.2	48.7	3.0
LUBBOCK, TEX.	179.3	156.3	23.0	1.5
LYNCHBURG, VA.	123.5	110.7	12.8	1.2
MACON, GA.	206.3	180.4	25.9	1.4
MADISON, WIS.	290.3	222.1	68.2	3.1
MANCHESTER, N.H.	108.5	102.9	5.6	0.5
MANSFIELD, OHIO	130.0	117.8	12.2	1.0
MC ALLEN-PHARR-EDINBURG, TEX.	181.5	180.9	0.6	0.0
MEMPHIS, TENN.-ARK.	770.1	674.6	95.5	1.4
MERIDEN, CONN.	56.0	51.9	4.1	0.8
MIAMI, FLA.	1267.8	935.0	332.8	3.6
MIDLAND, TEX.	65.4	67.8	-2.4	-0.4
MILWAUKEE, WIS.	1403.9	1278.8	125.1	1.0
MINNEAPOLIS-ST. PAUL, MINN.	1813.6	1482.0	331.6	2.2
MOBILE, ALA.	376.7	363.4	13.3	0.4
MODESTO, CALIF.	194.5	157.3	37.2	2.4
MONROE, LA.	115.4	101.7	13.7	1.3
MONTGOMERY, ALA.	201.3	199.7	1.6	0.1
MUNCIE, IND.	129.2	110.9	18.3	1.7
MUSKEGON-MUSKEGON HGTS. MICH.	157.4	149.9	7.5	0.5
NASHVILLE, TENN.	540.9	463.6	77.3	1.7
NASHUA, N.H.	66.5	45.0	21.5	4.8
NEWARK, N.J.	1856.6	1689.4	167.2	1.0
NEW BEDFORD, MASS.	152.6	143.2	9.4	0.7
NEW BRITAIN, CONN.	145.3	129.4	15.9	1.2
NEW HAVEN, CONN.,	355.5	320.8	34.7	1.1
NEW LONDON-GROTON-MORWICH, CONN.	208.7	171.0	37.7	2.2
NEWPORT NEWS-HAMPTON, VA.	292.2	244.5	67.7	3.0
NEW ORLEANS, LA.	1046.5	907.1	139.4	1.5
NEW YORK, N.Y.	11528.6	10694.1	834.0	0.8
NORFOLK, PORTSMOUTH, VA.	680.6	578.5	102.1	1.8
NORWALK, CONN.	120.1	96.8	23.3	2.4
ODESSA, TEX.	91.8	91.0	0.8	0.1
OGDEN, UTAH	126.3	110.7	13.6	1.4
OKLAHOMA, OKLA.	640.9	511.8	129.1	2.5

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
OMAHA, NEBR. IOWA	541.5	457.9	83.6	1.8
ORLANDO, FLA.	428.0	318.5	109.5	3.4
OWENSBORO, KY.	79.5	70.6	8.9	1.3
OXNARD-CONN.	376.4	199.1	177.3	8.9
PATERSON-CLIFTON-PASSAIC, N.J.	1358.8	1186.9	171.9	1.4
PENSACOLA, FLA.	243.1	203.4	39.7	2.0
PEORIA, ILL.	342.0	313.4	28.6	0.9
PETERSBURG-COLONIAL HEIGHTS, VA.	128.8	106.7	22.1	2.1
PHILADELPHIA, PA.	4617.9	4342.9	475.0	1.1
PHOENIX, ARIZ.	968.5	663.5	305.0	4.6
PINE BLUFF, ARK.	85.3	81.4	3.9	0.5
PITTSBURG, PA.	2401.2	2405.4	-4.2	-0.0
PITTSFIELD, MASS.	79.9	76.8	2.9	0.4
PORTLAND, ME.	141.6	139.1	2.5	0.2
PORTLAND, ORE.-WASH.	1009.1	821.9	187.6	2.3
PROVIDENCE-PAWTUCKET-WARWICK, R.I. MASS.	914.1	821.1	93.0	1.1
PROVO-OREM, UTAH	137.8	107.0	30.8	2.9
PUEBLO, COLO.	118.2	118.7	-0.5	-0.0
RACINE, WIS.	170.8	141.8	29.0	2.0
RALEIGH, N.C.	228.5	169.1	59.4	3.5
READING, PA.	296.4	275.4	21.0	0.8
RENO, NEV.	121.1	84.7	36.4	4.3
RICHMOND, VA.	518.3	436.0	82.3	1.9
ROANOKE, VA.	181.4	158.8	22.6	1.4
ROCHESTER, MINN.	84.1	65.5	18.6	2.8
ROCHESTER, N.Y.	882.7	73.6	150.1	2.0
ROCKFORD, ILL.	272.1	230.1	42.0	1.8
SACRAMENTO, CALIF.	800.6	625.5	175.1	2.8
SAGINAW, MICH.	219.7	190.8	28.9	1.5
SALEM, ORE.	186.7	147.4	39.3	2.7
SALINAS-MONTEREY, CALIF.	250.1	198.4	51.7	2.6
SALT LAKE CITY, UTAH	557.6	447.8	109.8	2.5
SAN ANGELO, TEX.	71.0	64.6	6.4	1.0
SAN ANTONIO, TEX.	864.0	716.2	147.8	2.1
SAN BERNARDINO-RIVERSIDE-ONTARIO, CAL.	1143.1	809.8	333.3	4.1
SAN DIEGO, CALIF.	1357.9	1033.0	324.9	3.1
SAN FRANCISCO-OAKLAND, CALIF.	3109.5	2648.8	460.7	1.7
SAN JOSE, CALIF.	1064.7	642.3	422.4	6.6
SANTA BARBARA, CALIF.	264.3	169.0	95.3	5.6
SANTA ROSA, CALIF.	204.9	147.4	57.5	3.9

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
SAVANNAH, GA.	187.8	188.3	-0.5	-0.0
SCRANTON, PA.	234.1	234.5	-0.4	-0.0
SEATTLE-EVERETT, WASH.	1421.9	1107.2	314.7	2.8
SHERMAN-DENISON, TEX.	83.2	73.0	10.2	1.4
SHREVEPORT, LA.	293.9	281.5	12.4	0.4
SIOUX FALLS, S.D.	95.2	86.6	8.6	1.0
SIOUX CITY, IOWA	116.2	120.0	-3.8	-0.3
SOUTH BEND, IND.	280.0	271.1	8.9	0.3
SPOKANE, WASH.	287.5	278.3	9.2	0.3
SPRINGFIELD-CHICOPEE-HOLYOKE, MASS.	529.9	494.0	35.9	0.7
SPRINGFIELD, ILL.	161.3	146.5	14.8	1.0
SPRINGFIELD, OHIO	157.1	131.4	25.7	2.0
SPRINGFIELD, MO.	152.9	126.3	26.6	2.1
ST. JOSEPH, MO.	86.9	90.6	-3.7	-0.4
ST.LOUIS, MO-ILL.	2363.0	2104.7	258.3	1.2
STANFORD, CONN.	206.4	178.4	28.0	1.6
STEUBENVILLE-WEIRTON, OHIO-W. VA.	165.6	167.8	-2.2	-0.1
STOCKTON, CALIF.	290.2	250.0	40.2	1.6
SYRACUSE, N.Y.	635.9	563.8	72.1	1.3
TACOMA, WASH.	411.0	321.6	89.4	2.8
TALLAHASSEE, FLA.	103.0	74.2	28.8	3.9
TAMPA-ST. PETERSBURG, FLA.	1012.6	772.5	240.1	3.1
TERRE HAUTE, IND.	175.1	172.1	3.0	0.2
TEXARKANA, TEX.-ARK.	101.2	91.7	9.5	1.0
TOLEDO, OHIO-MICH.	692.6	630.6	62.0	1.0
TOPEKA, KAN.	155.3	141.3	14.0	1.0
TRENTON, N.J.	304.0	266.4	37.6	1.4
TUCSON, ARIZ.	351.7	265.7	86.0	3.2
TULSA, OKLA.TUSCALOOSA, ALA.	475.9	419.0	56.0	1.4
TUSCALOOSA, ALA.	116.0	109.0	7.0	0.6
TYLER, TEX.	97.1	86.4	10.7	1.2
UTICA-ROME, N.Y.	340.5	330.8	9.7	0.3
VALEJO-NAPA, CALIF.	249.1	200.5	48.6	2.4
VINELAND-MILLVILLE-BRIDGETON, N.J.	121.4	106.9	14.5	1.4
WACO, TEX.	147.6	150.1	-2.5	-0.2
WASHINGTON, D.C.-MD.-VA.	2861.1	2076.6	784.5	3.8
WATERBURY, CONN.	209.0	185.5	23.5	1.3
WATERLOO, IOWA	132.9	122.5	10.4	0.8
WEST PALM BEACH, FLA.	348.8	228.1	120.7	5.3
WHEELING, W. VA.-OHIO	182.7	190.3	-7.6	-0.4

	POP 70	POP 60	CHG 60-70	ANN PCT CHG
WICHITA FALLS, TEX.	127.6	129.6	-2.0	-0.2
WICHITA, KAN.	389.4	381.6	7.8	0.2
WILKES-BARRE-HAZELTON, PA.	342.3	347.0	-4.7	-0.1
WILMINGTON, DEL.-N.J.-MD.	499.5	414.6	84.9	2.0
WILMINGTON, N.C.	107.2	92.0	15.2	1.7
WORCESTER, MASS.	344.3	328.9	15.4	0.5
YORK, PA.	329.5	290.2	39.3	1.4
YOUNGSTOWN-WARREN, OHIO	536.0	509.0	27.0	0.5



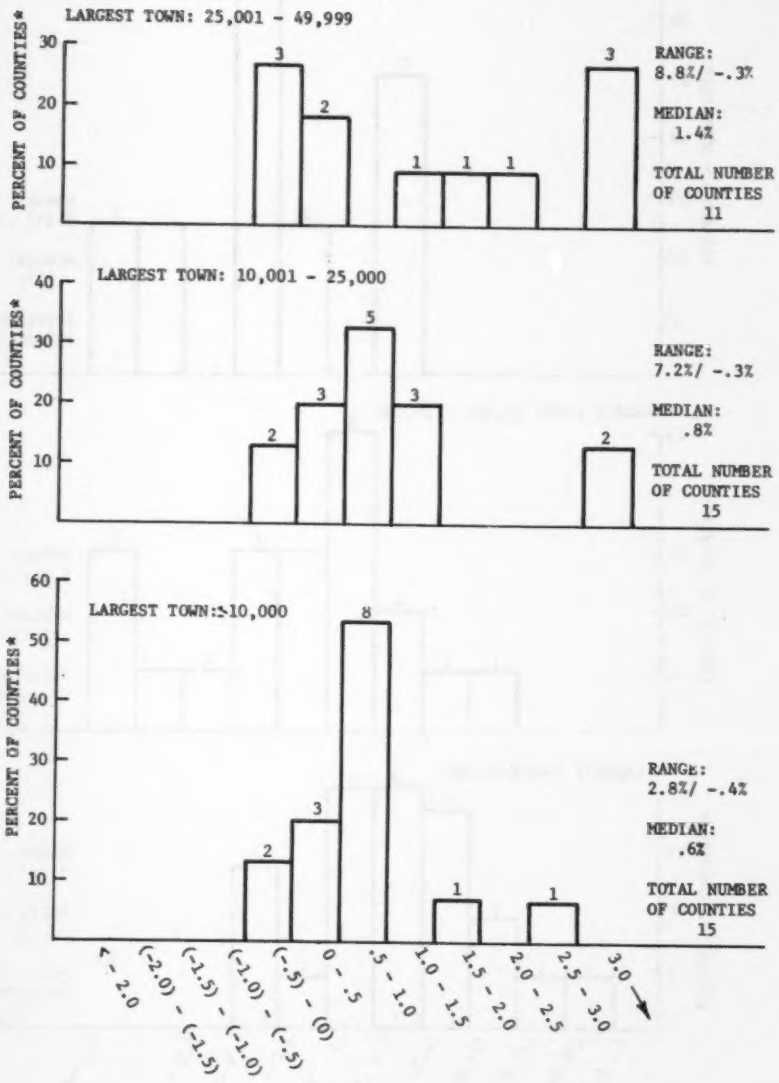
*Number above bar indicates actual number of counties in category

FIGURE 1

BOSTON REGION

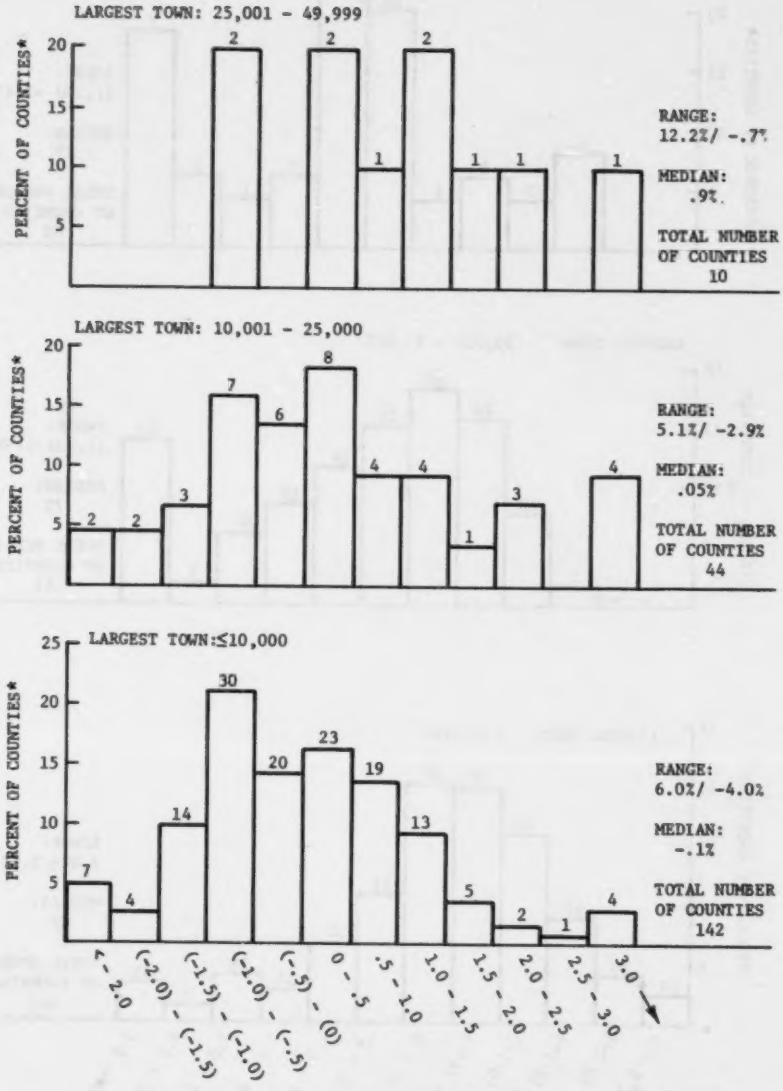
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH

PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



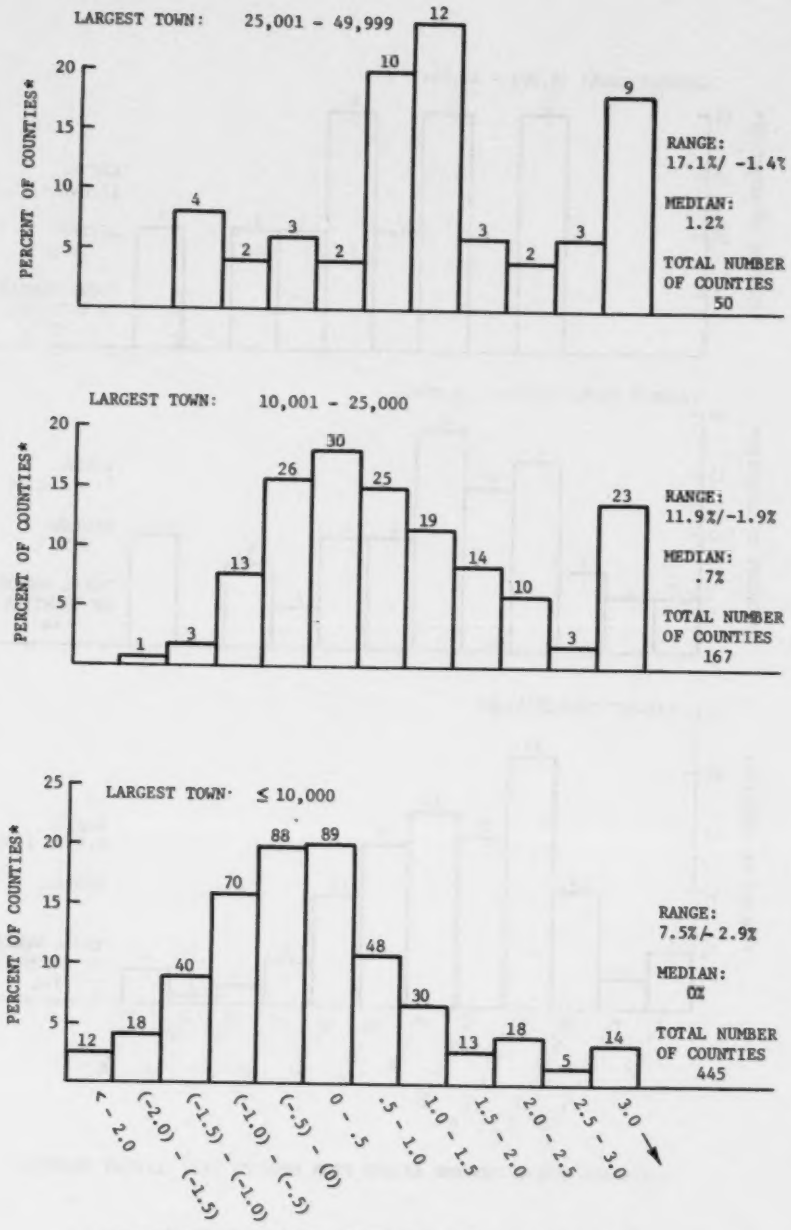
*Number above bar indicates actual number of counties in category

FIGURE 2
NEW YORK REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



*Number above bar indicates actual number of counties in category

FIGURE 3
PHILADELPHIA REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



AVERAGE ANNUAL PERCENT CHANGE FROM 1960 TO 1970 (LINEAR GROWTH)

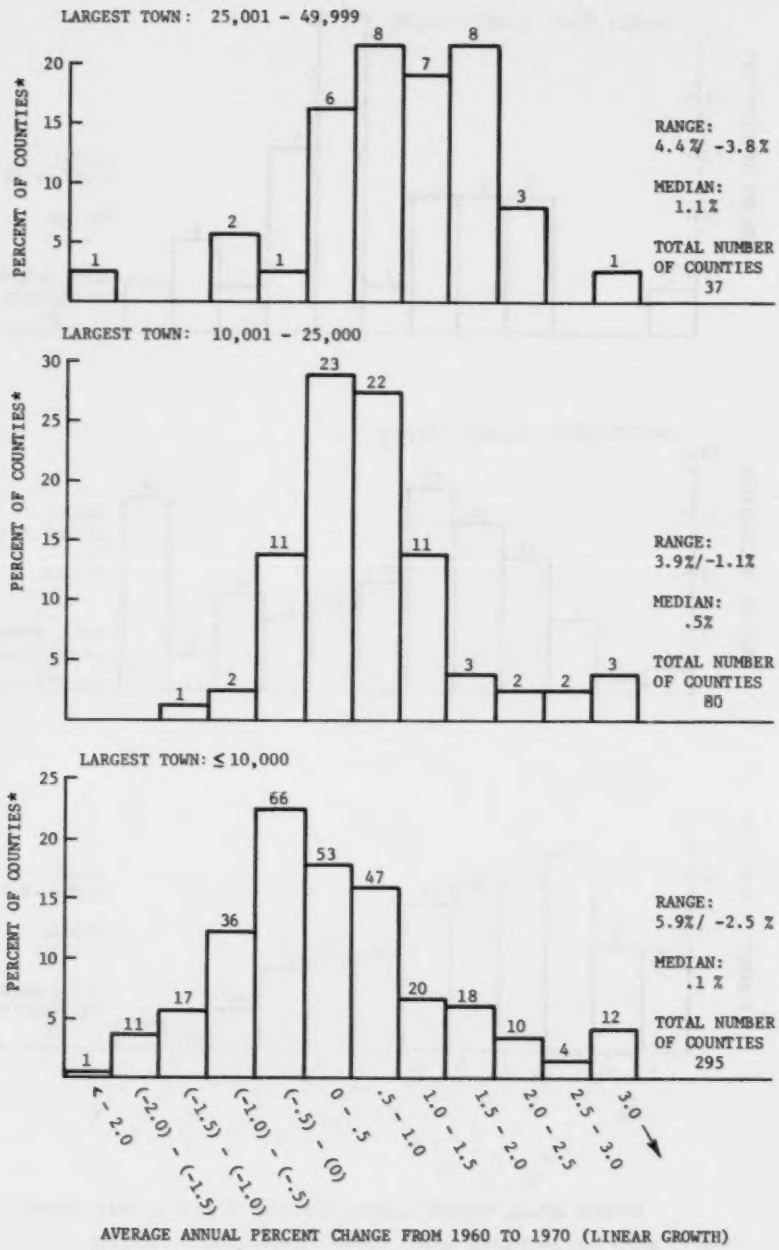
*Number above bar indicates actual number of counties in category

FIGURE 4

ATLANTA REGION

NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH

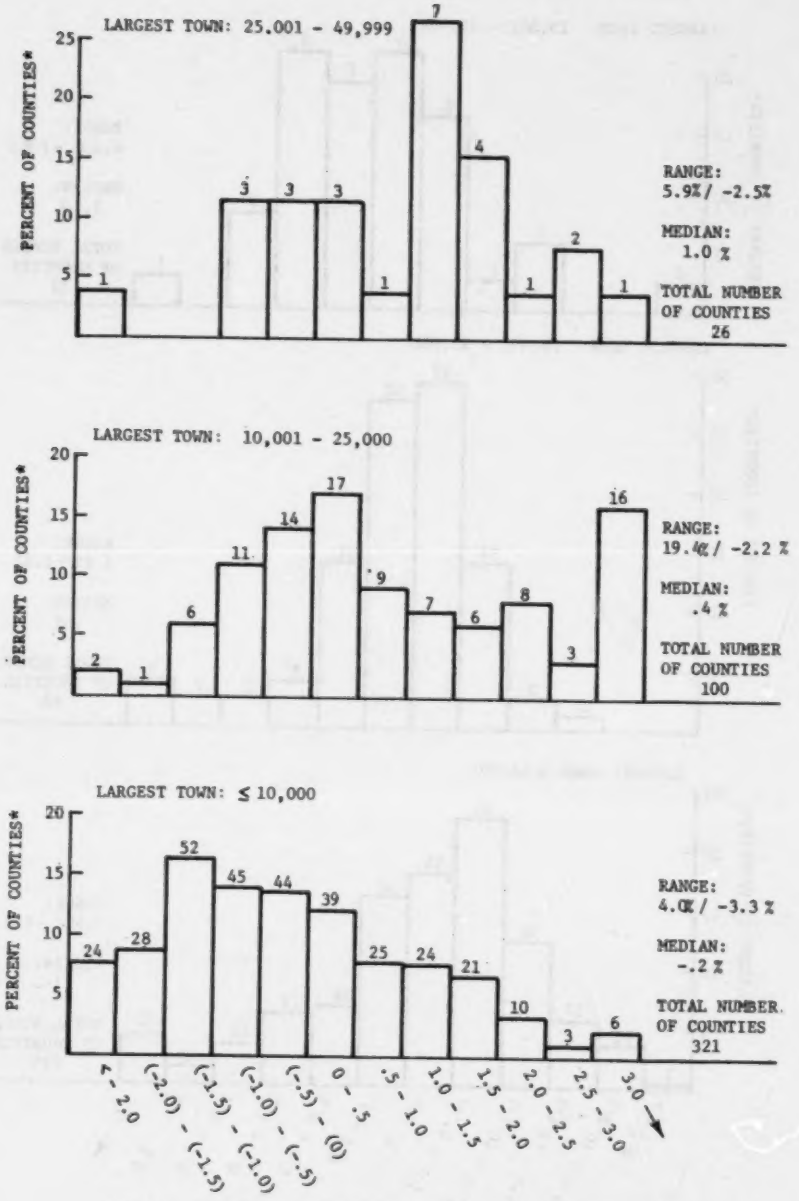
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



AVERAGE ANNUAL PERCENT CHANGE FROM 1960 TO 1970 (LINEAR GROWTH)

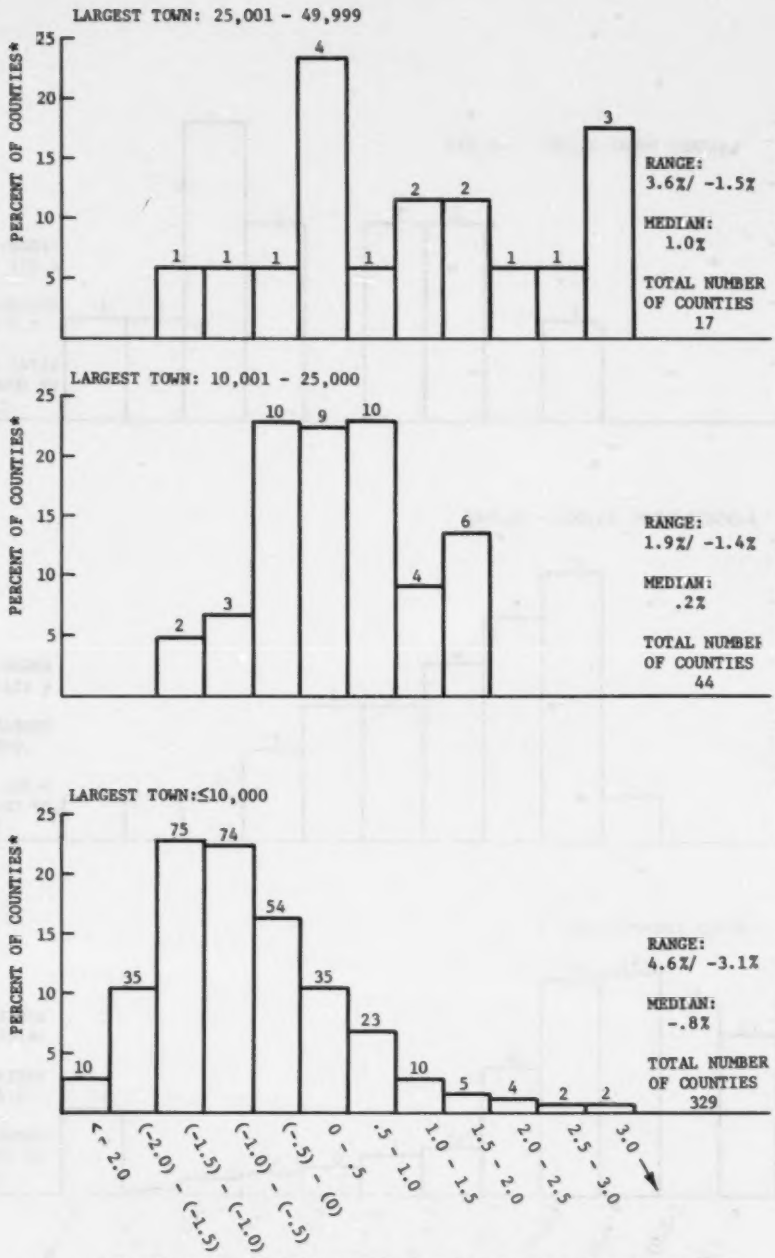
*Number above bar indicates actual number of counties in category

FIGURE 5 CHICAGO REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



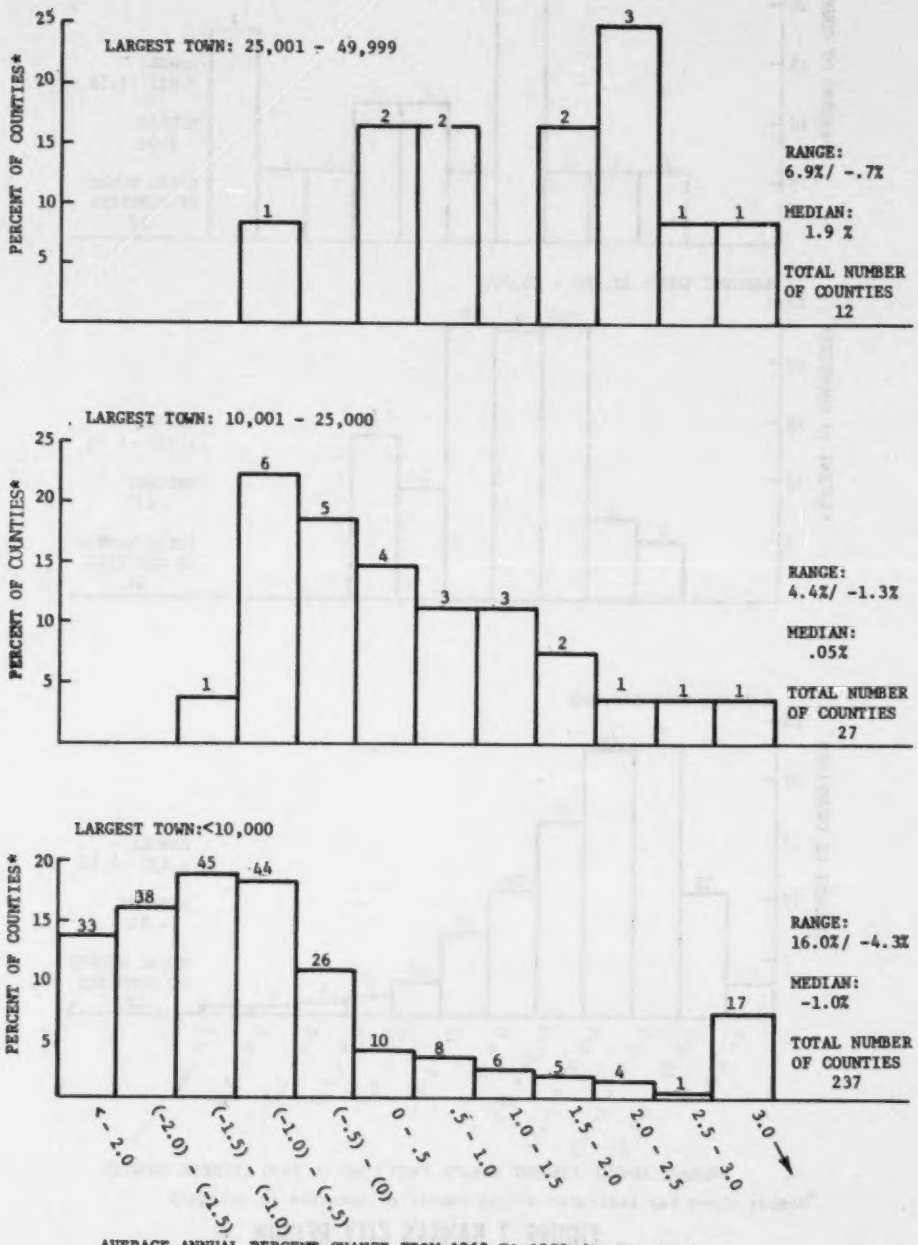
*Number above bar indicates actual number of counties in category

FIGURE 6 DALLAS REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



*Number above bar indicates actual number of counties in category

FIGURE 7 KANSAS CITY REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



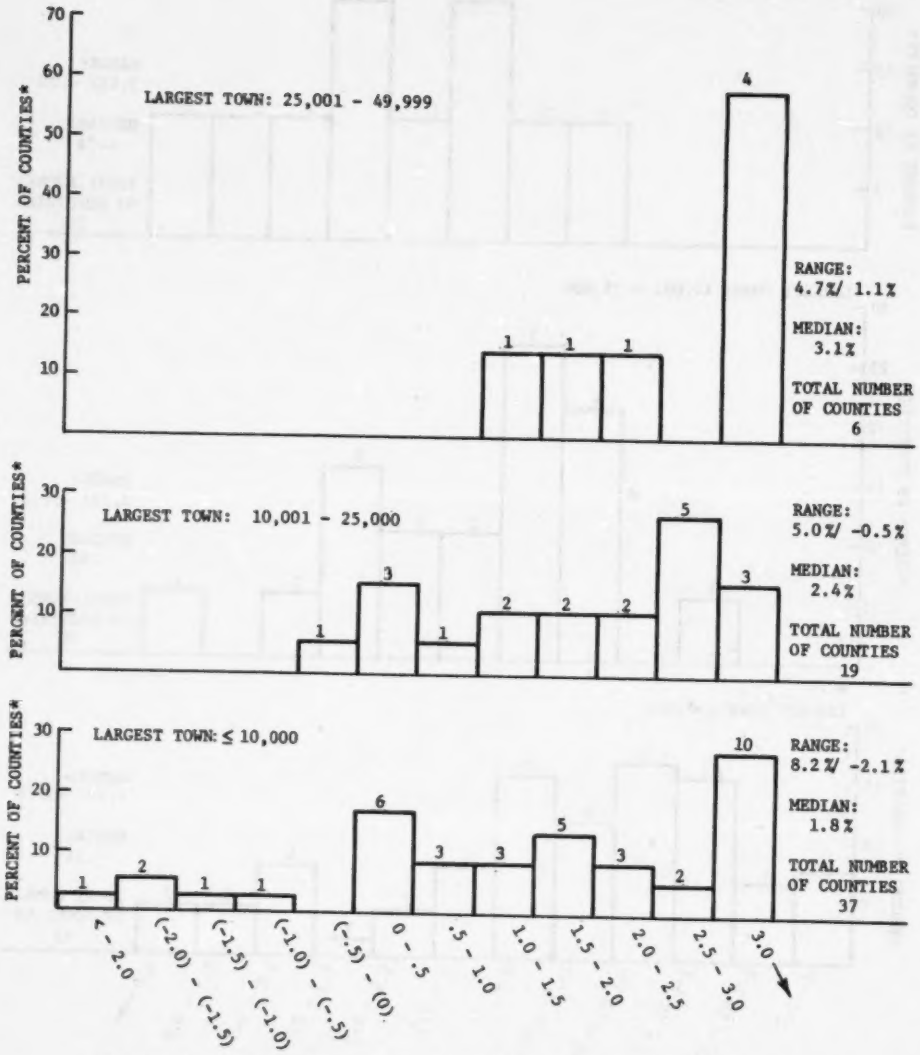
AVERAGE ANNUAL PERCENT CHANGE FROM 1960 TO 1970 (LINEAR GROWTH)

*Number above bar indicates actual number of counties in category

FIGURE 8 DENVER REGION

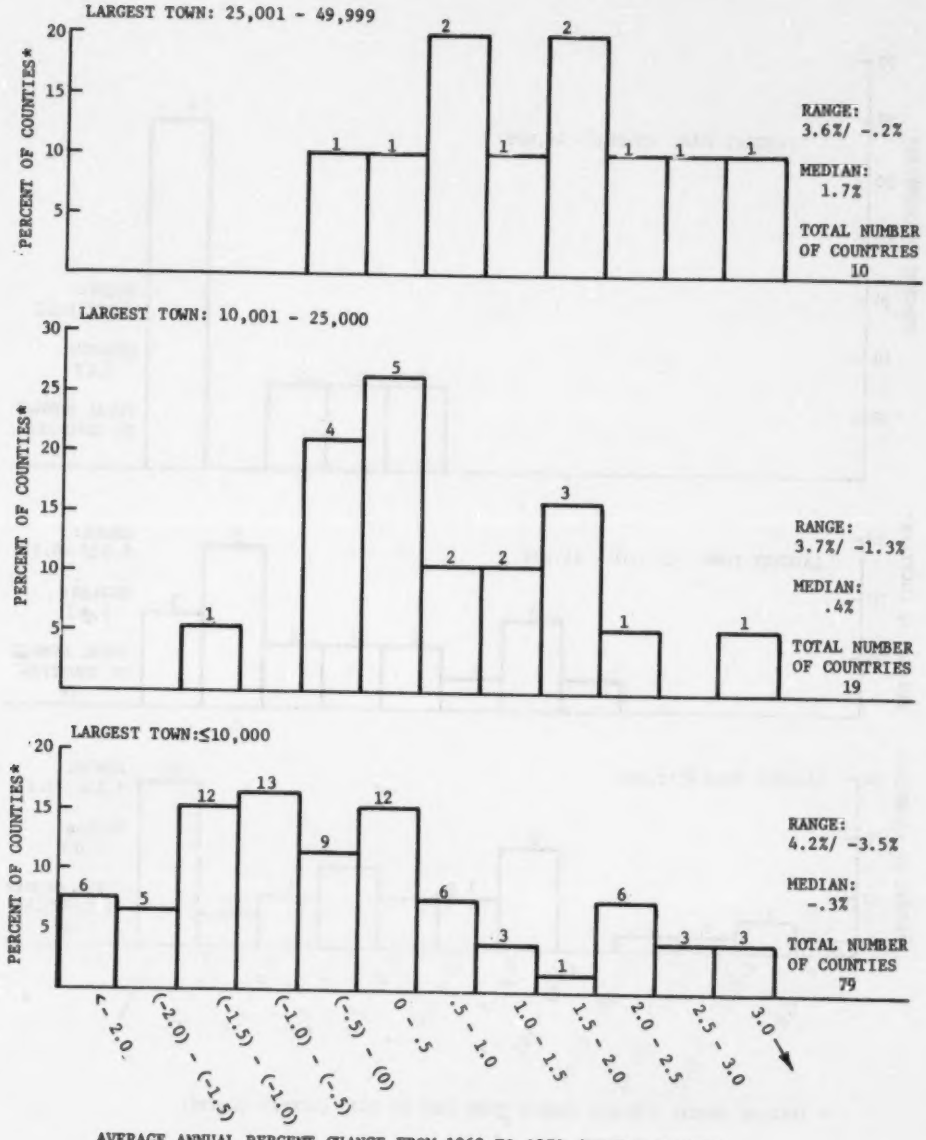
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH

PERCENT OF OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



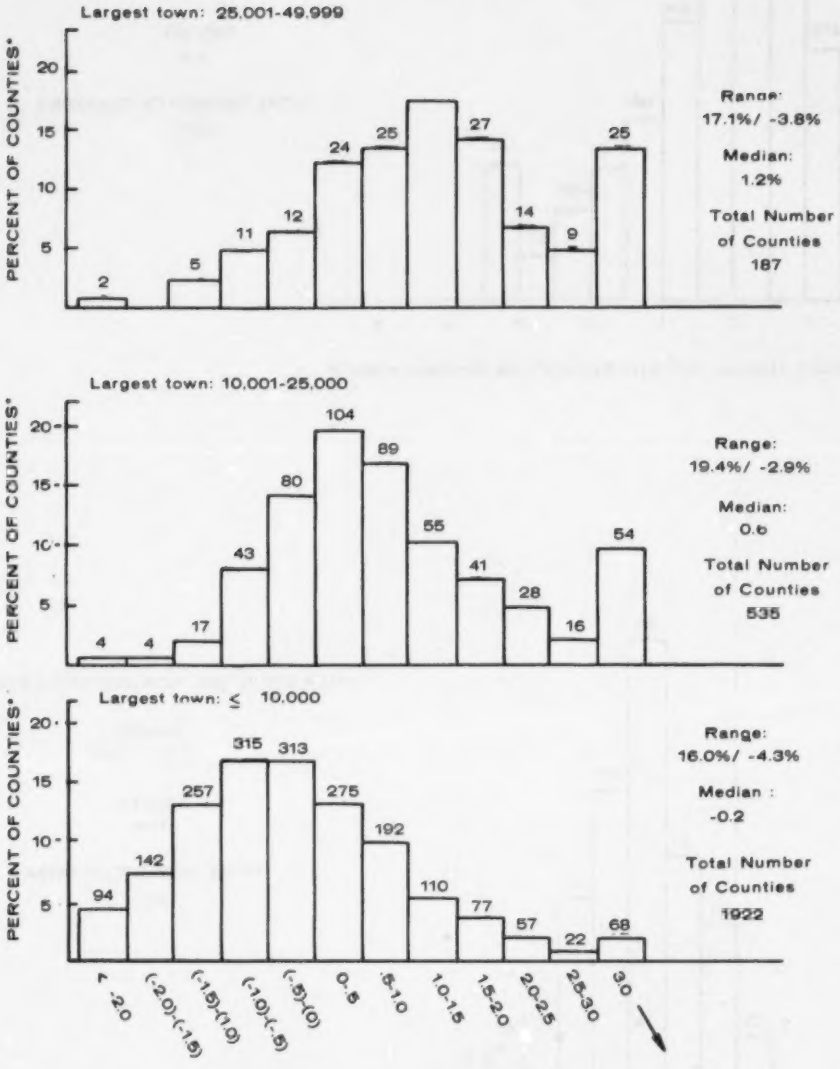
*Number above bar indicates actual number of counties in category

FIGURE 9 SAN FRANCISCO REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



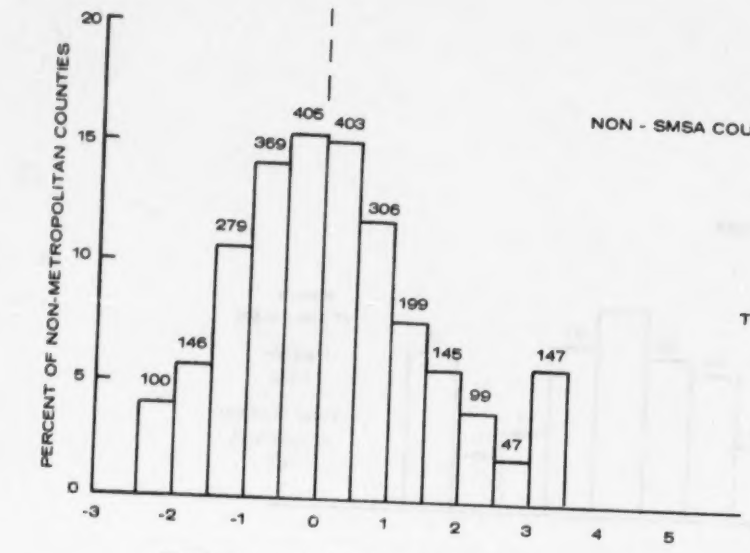
*Number above bar indicates actual number of counties in category

FIGURE 10 SEATTLE REGION
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH
PERCENT OF COUNTIES BY SIZE OF PRINCIPAL CITY OR TOWN



average annual percent from 1960 to 1970 (linear growth)
*number above bar indicates actual number of counties in category

FIGURE 11
NON-SMSA COUNTIES, 1960-1970, POPULATION GROWTH PERCENT OF COUNTIES BY NATIONAL SUMMARY OF PRINCIPAL CITY OR TOWN

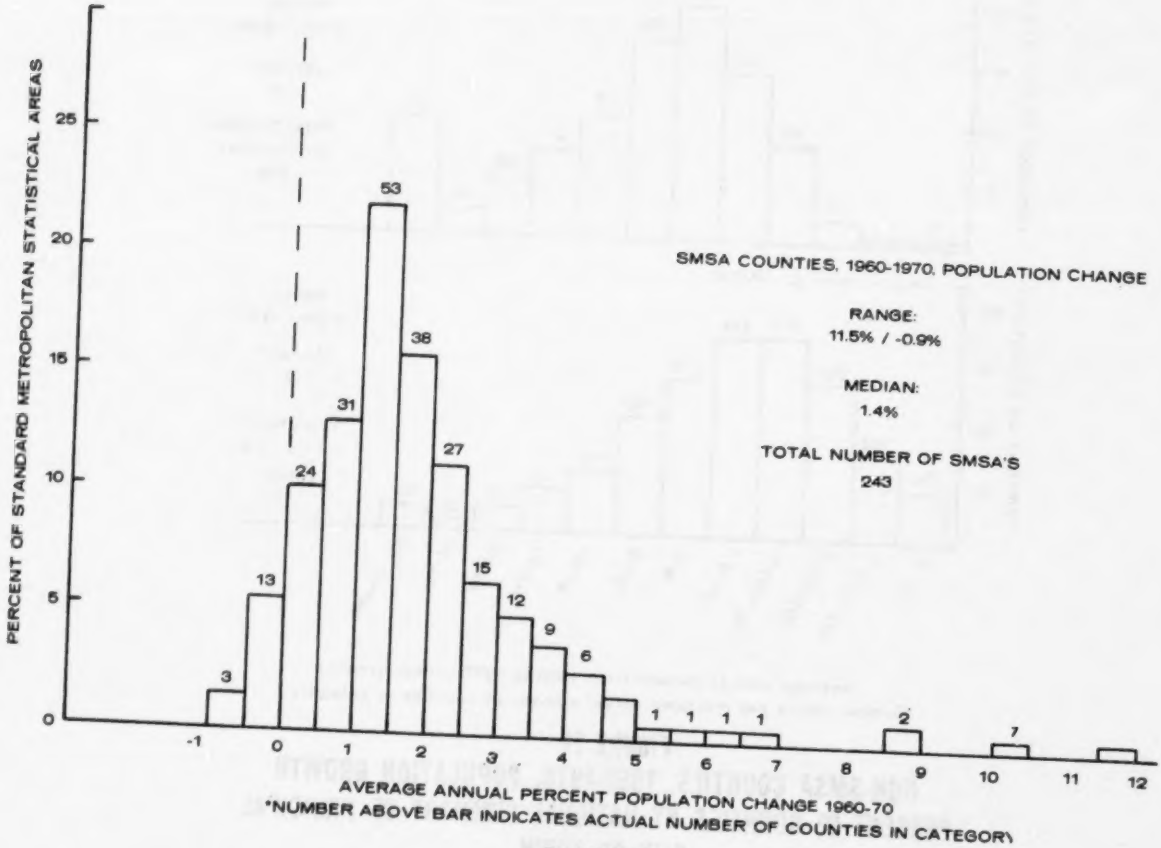


NON - SMSA COUNTIES, 1960-1970, POPULATION CHANGE

RANGE:
19.4% -4.3%

MEDIAN:
0%

TOTAL NUMBER OF COUNTIES
2644



SMSA COUNTIES, 1960-1970, POPULATION CHANGE

RANGE:
11.5% / -0.9%

MEDIAN:
1.4%

TOTAL NUMBER OF SMSA'S
243

FIGURE 12

COMPARISON OF NON-SMSA'S AND SMSA'S RATE OF POPULATION CHANGE, 1960-1970

* U. S. GOVERNMENT PRINTING OFFICE : 1972—514-150 (121)